Yield of Potato as Influenced by Crop Sanitation and Reduced Fungicidal Treatments

D.A. Fontem*

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Summary

The effects of crop sanitation and reduced sprays of «Ridomil plus®» (12 % metalaxyl + 60 % cuprous oxide) on the control of potato (Solanum tuberosum) *late blight caused by* Phytophthora infestans *were evaluated in two field experiments in 1993 in Dschang, Cameroon. In the first experiment, sanitation (five weekly removals of blighted leaves) and two fungicidal treatments were initiated from first symptoms. In the second experiment, both fungicidal sprays were made at varying rates. Marketable yields increased by 50 % in sanitation-treated plots, by 94 % in plots sprayed with Ridomil plus (2.24 kg a.i./ha), or by 55 % in those exposed to both control methods. The fungicide equivalence of the sanitation treatment was two sprays of Ridomil plus at 0.76 kg a.i./ha. These results suggest that proper removal of diseased leaves or reduced fungicidal protection may be an effective late blight control method in potato farming.*

Résumé

Les effets du nettoyage sanitaire et des traitements réduits au «Ridomil plus®» (12 % de métalaxyl + 60 % d'oxyde cuivreux) sur la lutte contre le mildiou de la pomme de terre (Solanum tuberosum) *causé par* Phytophthora infestans, *ont été évalués dans deux essais en 1993 à Dschang, Cameroun. Dans le premier essai, le nettoyage sanitaire (cinq prélèvements hebdomadaires des feuilles atteintes) associé à deux traitements fongicides, ont été initiés dès les premiers symptômes. Dans le deuxième, des traitements fongicides ont été appliqués à des doses variables. Les rendements commercialisables ont augmenté de 50 % dans les parcelles soumises au nettoyage sanitaire, de 94 % dans celles traitées au Ridomil plus (2,24 kg m.a./ha), ou de 55 % dans celles soumises aux deux méthodes de lutte. L'équivalence, en traitements fongicides, du nettoyage sanitaire fut de deux pulvérisations au Ridomil plus à 0,76 kg m.a./ha. Ces résultats suggèrent qu'un prélèvement approprié des feuilles malades ou une réduction des traitements fongicides, peuvent être envisagés pour lutter efficacement contre le mildiou de la pomme de terre.*

1. Introduction

Potato late blight, caused by *Phytophthora infestans* (Mont.) dBy, is the most important production constraint of potato *Solanum tuberosum* L. Tuber losses have been estimated at up to 71 % in Cameroon (4), where potato growers usually control this disease with intensive applications of fungicides. However, concerns about the safety of farm workers, environmental pollution, and production costs have stimulated researchers to incorporate a reduced-sprays strategy in the management of this disease (9). Fontem and Aighewi reported that two applications of «Ridomil plus®», a pre-packed mixture of 12 % metalaxyl + 60 % cuprous oxide, were more effective in limiting late blight progress and increasing potato yields than six weekly sprays of maneb, mancozed, or cupric hydroxide (4).

Fungicides are not always available to resource-poor farmers, and consequently, the adoption of an alternative, less expensive and less polluting method, such as crop sanitation, would be a sound strategy for a sustainable management of this disease. Sanitation, a process that reduces the initial inoculum from which epidemics start, has been reported to delay the onset of potato late blight with a subsequent increase in yields (10). In potato cultivation, sanitation is usually practised as the elimination of volunteer crops, cull piles, and alternate hosts (5, 10, 11), while the effect of the removal of diseased leaf tissue in the field on late blight development or potato yield is not well known.

The major aim of this study was to assess the impact of using crop sanitation (weekly removal of blighted leaves) and reduced fungicidal applications on late blight severity and potato yield.

2. Material and methods

Two field experiments were conducted in the 1993 cropping season in Dschang, Cameroon. The soil type and the climatic data for this location have previously been described (3).

*Plant Protection Department, University of Dschang, Box 208 Dschang, Cameroon.

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2.1. Crop sanitation and fungicidal applications

In the first experiment, a randomized complete block design was used with four replicates. Experimental units consisted of four rows 4.8 m long and 0.8 m wide. Plots were separated by a potato-free zone 4 m wide to limit inter-plot interference. A local potato cultivar «Tezelfeu» was planted manually on 6 April. Plants were spaced 0.3 m between rows.

Plots were fertilized with 144-72-200 kg/ha N-P-K in bands at planting. A foliar fertilizer, Fertigofol 313 (4 L/ha), was applied on the leaves one month after planting. An insecticide-nematicide, carbofuran (Furadan® 10G, 3 kg a.i./ha), was applied after planting but before emergence. Plots were manually weeded and hilled as needed.

Crop sanitation, initiated from the first symptoms (42 days after planting, DAP), was made by five weekly removal of diseased leaves. Fungicide treatments were achieved with two foliar sprays of Ridomil plus (72WP, 2.24 kg a.i./ha). The first spray was made 42 DAP, and the second three weeks later, using a knapsack sprayer, delivering about 800 l/ha at a maximum pressure of 7 kg/cm^2. Treated plots received sanitation, fungicide, or both, while control plots were neither sprayed, nor cleaned from diseased leaves.

2.2. Rate of «Ridomil plus» application

The effect of the rate of application of Ridomil plus on late blight severity and potato yield was assessed in the second experiment. A randomized complete block design was used with three replicates. Experimental units, planting and maintenance were as indicated above. Fungicidal treatments were made with two foliar sprays of Ridomil plus at the rate of 0.28, 0.56, 1.12, 2.24 or 4.48 kg a.i./ha. The treatments were initiated, scheduled and performed as indicated above.

In both experiments, tubers were hand-harvested from the middle rows of each plot at 86 DAP. After discarding unmarketable and diseased tubers, marketable tubers were weighed, and yields were expressed as t/ha fresh weight.

2.3. Disease evaluation and data analyses

Inoculation was from naturally-occurring inocula in the field. Disease ratings, initiated 42 DAP, were made on a 7-day schedule on five randomly selected plants on the inner rows of each plot. Disease severity (percent leaf area diseased) was scored on the entire plant using the Horsfall-Barratt (6) rating scale, and the values obtained were converted to disease proportions.

Disease progress data were linearized with the logistic equation (10, 11). The initial disease (yo) and the logistic infection rate were calculated for each treatment as suggested by Vanderplank (10). The time to reach 50 % disease severity (t_{50}) was calculated for each treatment, using yo and the epidemic rate. Area under disease-progress curve (AUDPC) was computed as suggested by Shaner and Finney (8). Yield and AUDPC data were regressed on the fungicide rate, using multiple regression or log equations. Data were analyzed statistically with an MSTAT-C statistical package and means were separated using the Student-Newman-Keuls test (P = 0.05).

3. Results

3.1. Crop sanitation and fungicidal applications

There was a significant reduction in initial disease severity when crop sanitation was used alone or in combination with Ridomil plus. Although initial disease was least in plots treated with both sanitation and Ridomil plus, the applications of fungicide alone did not significantly affect the level of the initial disease, when compared to the control (Table 1).

Table 1
Initial disease (yo), time to reach 50 % disease severity (t_{50}), epidemic rate, and area under disease-progress curve (AUDPC) of potato late blight as influenced by crop sanitation and Ridomil plus treatments

Treatment	yo[y]	t_{50}	rate	AUDPC
Control	-13.53 a[z]	66	0.205 b	6.30 a
Sanitation	-16.17 b	74	0.219 ab	2.59 b
Ridomil plus	-12.84 a	75	0.171 c	3.39 b
Sanitation + Ridomil plus	-17.99 c	74	0.243 a	2.95 b

y Values obtained from the logistic transformation
z Means within a column followed by the same letter are not significantly different (P = 0.05) according to Student-Newman-Keuls test.

Time to reach 50 % blight severity on leaves was higher in all treated plots than in the control. Accordingly, the benefit of a control method (computed as a delay in reaching 50 % blight severity) was 8-9 days in the treated plots. Progress of late blight was fastest in plots receiving both sanitation and fungicide control methods and slowest in those treated with the fungicide alone. The epidemic rate obtained on plants exposed to sanitation alone was not significantly different from that recorded on untreated plants. Both sanitation and Ridomil plus treatments similarly reduced AUDPC, when used singly or in combination (Table 1).

Treatments with sanitation or fungicide improved the percent marketable tubers. However, applications of sanitation + Ridomil plus did not significantly affect this variable, compared to the control (Table 2). Yields obtained in sanitation plots were higher than those in the untreated plots but not significantly different from those obtained in plots exposed to both methods of protection. Average marketable yields increased by 50 % in sanitation plots, by 94 % in plots sprayed with Ridomil plus alone, or by 55 % in those protected with sanitation + Ridomil plus (Table 2).

Table 2
Percent marketable tubers and marketable yield (t/ha) of potato as influenced by crop sanitation and Ridomil plus control of late blight

Treatment	% marketable tubers	marketable yield
Control	53 b[z]	8.03 (-) c
Sanitation	71 a	12.01 (50) b
Ridomil plus	72 a	15.59 (94) a
Sanitation + Ridomil plus	61 ab	12.44 (55) b

z Means within a column followed by the same letter are not significantly different (P = 0.05) according to Student-Newman-Keuls test. Values in brackets are percent increase over the control.

3.2. Rate of fungicidal applications

The effect of the rate of application of Ridomil plus on the progress of late blight is presented in Fig. 1. The reduction in disease severity, after the initial fungicide application, was characteristic of reactions from fungicides with a curative mode of action. Disease progress from 50 DAP decreased with increase in fungicide rate (Fig. 1).

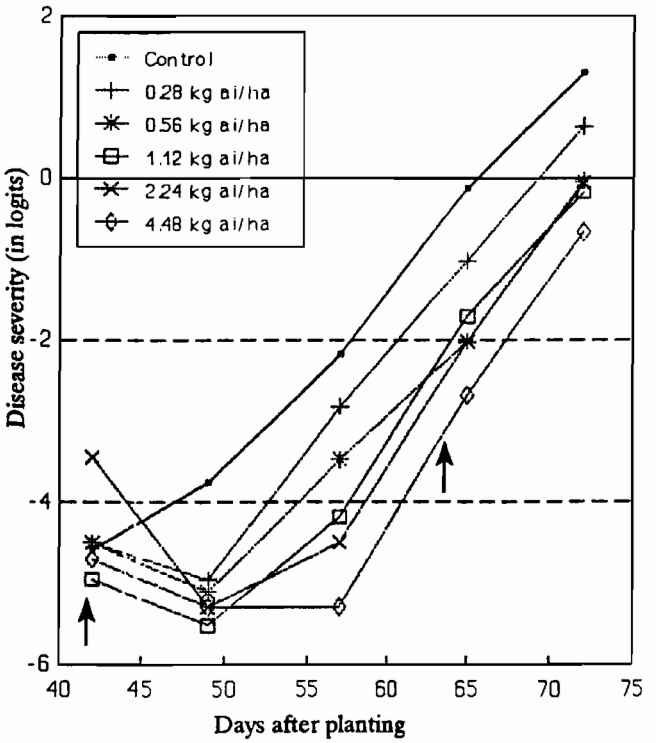

Fig. 1: Severity of potato late blight as influenced by the rate of application of Ridomil plus. Arrows indicate the dates of the applications.

In both experiments, marketable yields were negatively correlated with AUDPC. Both marketable yields and AUDPC were influenced by the amount of the fungicide sprayed. Marketable yields were described by the equation: Y (yields in t/ha) = 8.57 + 4.82x - 0.88x² (R^2 = 0.95, P = 0.05) where x is the rate of application of Ridomil plus. The application of 4.48 kg a.i./ha of Ridomil plus produced slight phytotoxic reactions on plants characterized by leaf distortion. The AUDPC was described by the equation: Y (AUDPC value) = 3.18 - 0.90*ln(x) (R^2 = 0.96, P = 0.001) (Fig. 2).

In the first equation above, the maximum yield (computed with dY/dx = 0) was obtained with the fungicidal application rate of 2.74 kg a.i./ha. Further increase in the rate of Ridomil plus decreased yields, apparently due to the phytotoxicity of the fungicide observed on the foliage. When yields obtained in the sanitation plots (12.01 t/ha) were substituted in the yield equation obtained from varying fungicide rates above, it was found that the sanitation treatment alone was equivalent to two foliar applications of 0.76 kg a.i./ha of Ridomil plus (Fig. 2).

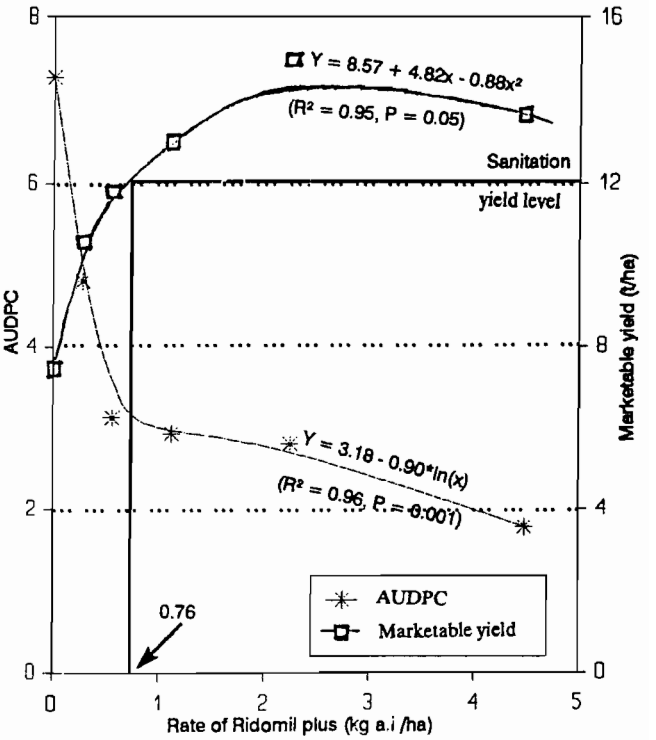

Fig. 2: Marketable yields of potato and area under disease-progress curve (AUDPC) of late blight, as affected by the rate of application of «Ridomil plus».

4. Discussion

Field sanitation is usually practised in agriculture to reduce initial disease severity (5, 7, 10, 11). In this study, a significant reduction in initial disease was observed in plots under sanitation, or sanitation + fungicide treatments. This reduction in initial disease was associated with a significant increase in the epidemic rate, apparently due to the availability of more leaf tissue for low levels of initial inoculum. Some researchers (1, 7) have also reported that in many pathosystem epidemics, low levels of initial disease are associated with increases in the epidemic rate.

A combination of sanitation with «Ridomil plus» did not provide any significant improvement on marketable yields over sanitation alone. Combined treatments were less efficient than the fungicide alone, suggesting that the effect of sanitation was inhibitory to that of the fungicide. Sanitation was practised by removing entire diseased leaves, thus depriving the plant of some of the photosynthetic tissue in the suppressed leaves. This could account for the lower yields recorded in plots treated with sanitation, or sanitation + «Ridomil plus».

Both marketable yields and AUDPC could be predicted according to the amount of fungicide sprayed on the crop. Although sanitation did not produce very high yields, compared to the fungicidal application, the former could be a substitute for the latter, with a fungicide equivalence of the sanitation treatment of 0.76 kg a.i./ha. Consequently, five weekly removals of blighted leaves corresponded to two foliar applications of Ridomil plus at 0.76 kg a.i./ha.

It is necessary to practise field sanitation in potato cultivation regularly, because the late blight pathogen is wind borne and the latent period of the disease is quite short (10). Considering the unavailability of resistant cultivars and the importance of the disease (2, 4, 5, 10), appropriate sanitation programmes or applications of fungicides are necessary in the management of this disease in potato. Although constant removal of blighted leaves is not feasible in large farms, resource-poor farmers may use this method as an alternative to the application of expensive fungicides.

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Literature

1. Berger R.D., 1988. The analysis of effects of control measures on the development of epidemics, pp. 125-149 in: K.J. Leonard & W.E. Fry (Editors), Plant Disease Epidemiology, vol. **2**, McGraw Hill, New York.
2. Fontem D.A., 1991. An assessment of potato diseases in the Western highlands of Cameroon. Biosciences Proceedings **2**:82-86.
3. Fontem D.A. & Aighewi B., 1992. Efficacy of fungicides on the progress of early blight and yield of potato in Cameroon. Tropicultura **10**:15-19.
4. Fontem D.A. & Aighewi B., 1993. Effect of fungicides on late blight control and yield loss of potato in the western highlands of Cameroon. Int. J. Pest Management **39**:152-155.
5. Henfling J.W., 1987. Late Blight of Potato: *Phytophthora infestans*. Technical Information Bull. 4. International Potato Centre, Lima, Peru. 25 pp. (2nd ed., revised).
6. Horsfall J.G. & Barratt R.W., 1945. An improved grading system for measuring plant diseases. Phytopathology **35**:655.
7. Plaut J.L. & Berger R.D., 1981. Infection rates in three pathosystem epidemics initiated with reduced disease severities. Phytopathology **71**:917-921.
8. Shaner G. & Finney R.E., 1977. The effect of nitrogen fertilization on the expression of slow mildewing resistance in Knox wheat. Phytopathology **67**:1051-1056.
9. Shtienberg D., Raposo R., Bergeron S.N., Legard D.E., Dyer A.T. & Fry W.E., 1994. Incorporation of cultivar resistance in a reduced-sprays strategy to suppress early and late blights on potato. Plant Disease **78**:23-26.
10. Vanderplank J.E., 1963. Plant Diseases: Epidemics and Control. Academic Press, New York, 349 pp.
11. Zadoks J.C. & Schein R.D., 1979. Epidemiology and Plant Disease Management. Oxford University Press, New York, 427 pp.

D.A. Fontem: Cameroonian, P.S. (plant pathology), Lecturer, Department of Plant Protection, University of Dschang, Cameroon.

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